Space Weather Technical Forecast

Issued on Saturday, 20 May 2023 at 13:33 Local

This technical forecast provides a four day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales

Space Weather Forecast Headline: Minor/Moderate R1/R2 radio blackouts Likely. Chance of G1/Minor Geomagnetic Storms Days 1-2 & 4.

Analysis of Space Weather Activity over past 24 hours

Solar Activity: Solar activity has been Moderate over the past 24 hours, with X-ray activity recorded at GOES16 showing several M-class flares. Flares have mostly originating from AR3311, the largest of these was an impulsive M6.4 observed at 20/0732UTC.

There are currently around eight sunspot regions on the visible disc, including one unnumbered small bipolar region that is developing narrowly in advance of AR3311. The largest and most active regions on the disc currently lie in the eastern hemisphere. AR3311 (Fac/Beta-Gamma) is the largest and most complex. The Mt Wilson classification of Beta-Gamma is less certain due to the narrow viewing angle hindering magnetic polarity observations in the group's many penumbrae, as it may also contain a Delta spot. AR3310, which produced an M9.6 on 16 May, is large but continues to lose complexity having recently been reclassified Hkx/Alpha. Many of the other regions on the disc were smaller dipoles or else unipolar groups, while the main changes were confined to AR3305 in the northwest, which saw proliferation of its intermediate spots.

The solar disc has seen numerous filaments become mobile or disappear in recent days, during the most recent 24-hour period a central filament was mobile for several hours at the start of the period, but perhaps not resulting in any lift-off, with no obvious subsequent ejecta on coronagraphs and in the northwest disc, another filament disappeared around 19/1300UTC, as seen on H-Alpha imagery. This may have been the origin of a narrow and faint CME heading north and west in coronagraph imagery, Enlil analysis suggests no Earth-directed component. Although a number of minor CMEs were observed during the period, none are currently thought to be Earth-directed.

Solar Wind / Geomagnetic Activity: The solar wind, as measured by ACE at L1, was suggestive of a slow regime for much of the period, however this transitioned into a CIR-like environment during the UTC evening, possibly a precursor to anticipated CH03/-.

The solar wind speed was at slow-ambient levels at the start of the period with a slowly rising trend from 310 km/s, becoming slightly elevated around 20/0020UTC. At 20/0330UTC there was a jump in winds to 460km/s, since then winds have fluctuated between slightly elevated and elevated. The solar wind density was initially below average soon increasing to average. Around 19/1800UTC density increased to above average, fluctuating throughout the UTC night with several peaks of around 30ppcc observed. Density values have recently fallen to below average. From 20/2000UTC IMF stepped up from the previously observed flat 5nT to Moderate to Strong levels, with a peak of 21nT at 20/0321UTC. The north-south component was initially small scale and stable, around +6nT, but this gave way to a larger magnitude and mostly anti-aligned (with Earth's field) in the UTC night, with a peak of -17nT. More recently, it has fluctuated between +10nT/-17nT. The phi angle was mostly positive (away from the Sun), but since 19/2300UTC the phi angle has been predominantly negative (towards the Sun) suggesting that the connection to a HSS from CH03/- has arrived.

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The net effect of the above solar wind measures was for largely Quiet to Unsettled (Kp0-3) activity, but with Minor-Moderate/G1-G2 Geomagnetic storming (Kp5-6) intervals observed 20/0000-0600UTC.

Energetic Particles / Solar Radiation: High energy proton flux (greater than 10MeV), as measured at GOES16 has remained at background levels throughout.
High energy electron flux (greater than 2MeV), as measured at GOES16 was at Normal Background to Moderate levels, with a diurnal peak of 318pfu at 19/1735UTC. The 24-hour integrated fluence has been well below Active levels. At 20/0001UTC, 4.04e6 integrated pfu was recorded.

Four-Day Space Weather Forecast Summary
Solar Activity: Solar activity is Likely to remain Moderate, with a Slight Chance of X-class throughout the period, AR3311 being the most likely source of these flares, and AR3305 to a lesser extent. No new large regions are expected to arrive, however AR3305 leaves the disc by Day 4 (23 May) leading to a slight decrease in flare risk by the very end of the forecast.

Solar Wind / Geomagnetic Activity: The only CME that features in the forecast at the time of writing is a southwest quadrant filament eruption from 17 May - possibly glancing Earth on or after the middle of the UTC day of 21 May (Day 2) to give a Chance of a G1/Minor Geomagnetic storm (Kp5).

Solar winds are expected to remain at or close to elevated levels through Day 1, enhanced by a minor coronal hole, CH03/-. Wind speeds are expected to wane during Day 2, before further enhancement due to the arrival of HSSs from CH05/- or more likely CH06/- during Days 3-4 (22-23 May).

Geomagnetic activity is expected to be initially mostly Quiet to Unsettled (Kp0-3), becoming mostly Unsettled or Active (Kp3-4) from Day 2 onwards associated with the combined effects of a potential CME glancing blow and subsequent HSS arrivals. Chance of G1/Minor Geomagnetic storm (Kp5) intervals at times throughout the period.

Energetic Particles / Solar Radiation: The high energy (greater than 10 MeV) proton flux carries a daily Slight Chance of S1, largely as a result of the eastern hemisphere spots, with this very gradually rising over the four days.
High energy electron flux (greater than 2MeV) will most likely remain at Normal Background levels throughout.

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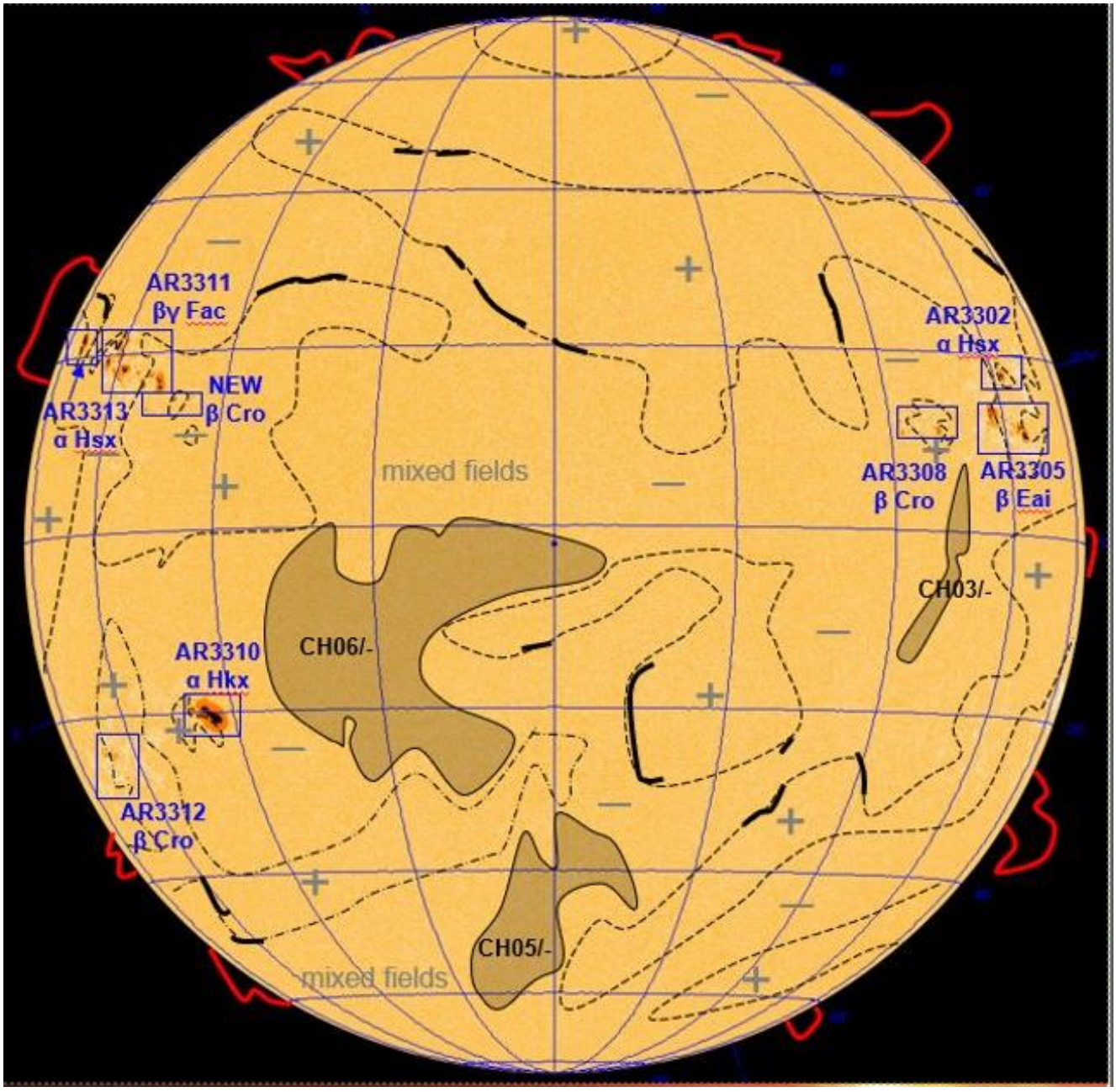
Figure 1. Solar Analysis Valid 20/0800UTC.



Key: Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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Geomagnetic Storms:

G1-G2/Minor to Moderate Geomagnetic storming intervals occurred 20/0000-0600UTC, this has been attributed to a CIR preceding the arrival of a HSS from CH03/-. Although CH03/- is a persistent feature, with a very similar appearance on AIA-211 to last pass, CME-derived geomagnetic activity at that time masked the strength of the feature, reducing confidence in its strength and behaviour for this rotation. Wind strengths are expected to ease through Day 2 (21 May) as in the influence of CH03/- wanes. The other features potentially due in the period are the near south polar CH05/-, which may result in a slight enhancement Days 3-4 (22-23 May), although in all likelihood it is likely too far from the ecliptic to produce a strong connection. CH06/-, which is visually significantly larger and more intense than CH03/-, is more advanced on this rotation than the last pass with a HSS anticipated to arrive at Earth on Day 4, however there is uncertainty in the arrival time. All considered, a fast wind in the region of 550-600km/s is considered most probable, giving a further Chance of G1/Minor Geomagnetic (Kp5) storming. SWPM is suggesting wind strengths in excess of 600 km/s towards the end of the period, which is not currently considered good guidance.

In the current forecast, one CME features at present attributed to a filament eruption that emanated from the southwestern quadrant of the Sun on 17 May. While the deterministic MOSWOC Enlil run is a miss, a significant minority of ensemble members display a glance on or after the middle (UTC) of Day 2 (21 May). This may result in residual effects into the new week, with a peak Slight Chance of a G1/Minor Geomagnetic storm (Kp5) interval on Day 2 or early Day 3 (22 May).

At the time of writing, no further CMEs are expected to arrive at Earth during the period.
In the absence of further CMEs, geomagnetic activity is expected to be mostly Quiet to Unsettled (Kp0-3) on Day 1 (20 May), becoming mostly Unsettled or Active (Kp3-4) from Day 2 onwards associated with the potential arrival of a glancing blow from a filament eruption CME and then subsequent arrivals of HSS from CH05/- and CH06/-. A lull in activity may be observed during Day 3 given the relatively low confidence in the timing of coronal hole enhancements.

Geo-Magnetic Storm Probability (Exceedance)	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Minor or Moderate	G1 to G2	Yes	20	20	10	30
Strong	G3	No	1	1	1	10
Severe	G4	No	1	1	1	1
Extreme	G5	No	1	1	1	1

Geomagnetic Activity - Earthbound Coronal Mass Ejections

Date/time 21.5R (UTC)	Halo: Full or Partial	Source	Source Location	Estimated Speed	Estimated Arrival Time	Comments
18/0316	Partial	Filament Eruption	SW	406km/s	21/1200UTC	Glancing blow or miss.

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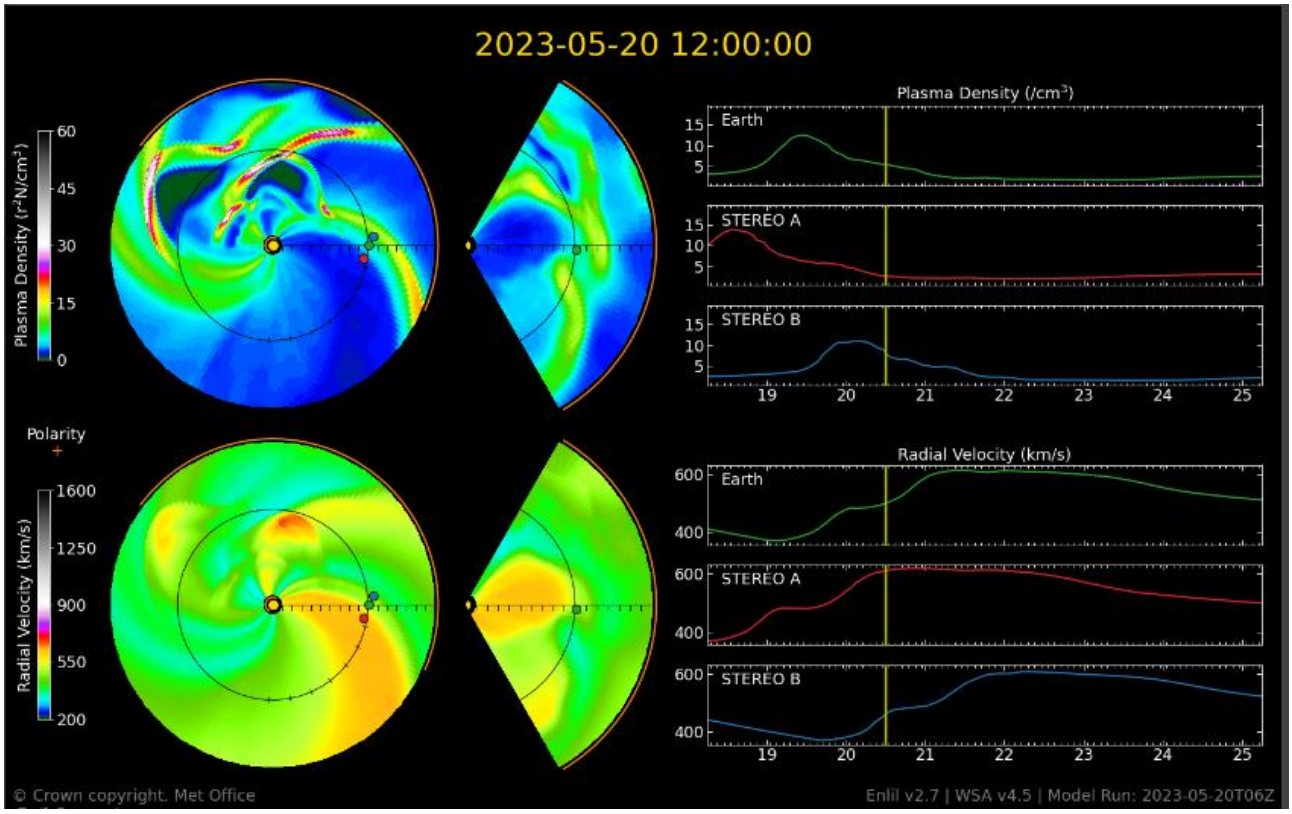
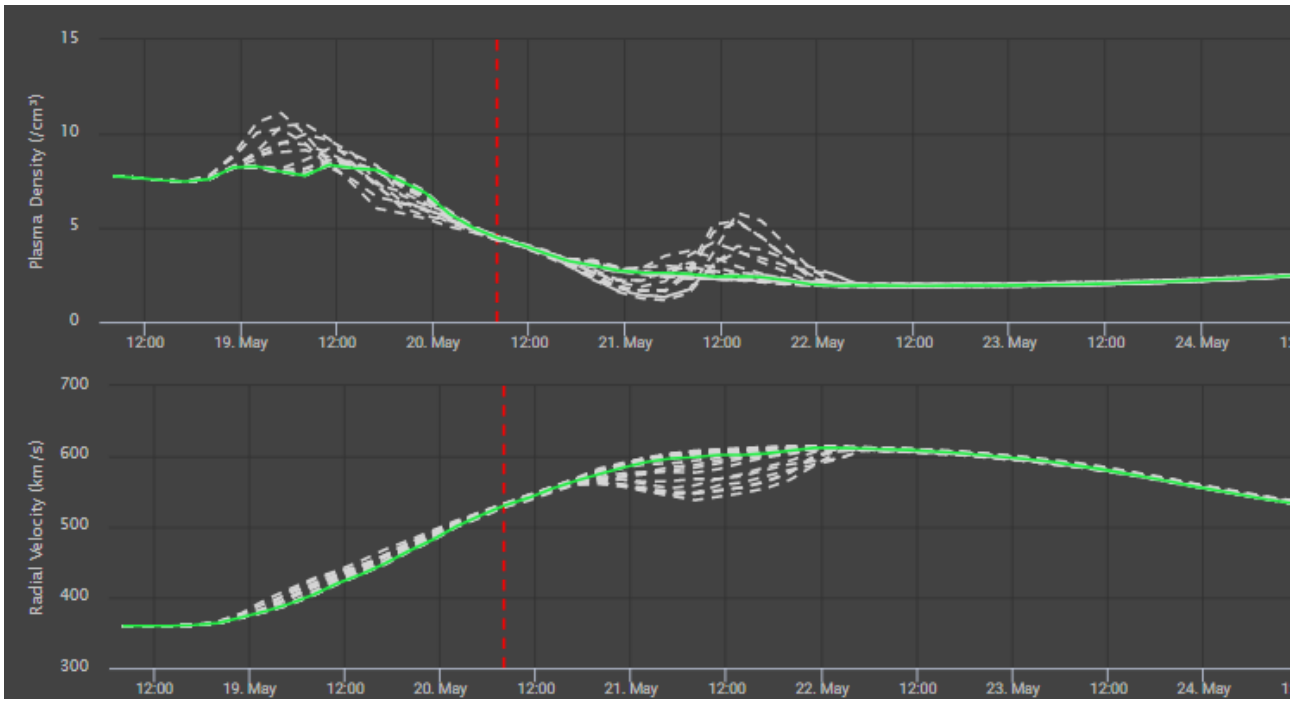
Figure 2: MOSWOC Enlil run and Ensemble. Some ensemble members showing glancing blow from 17 May southwest quadrant filament CME.





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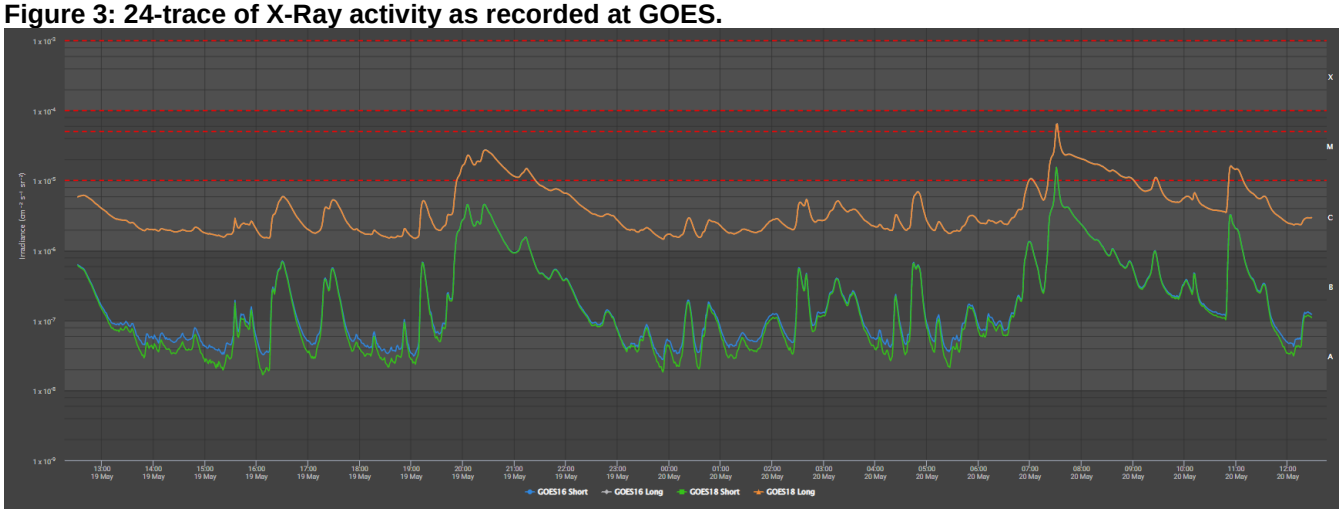
Radio Blackouts - X-Ray Flares:

The largest and most complex region on the disc, AR3311 is likely to remain the most active during the forecast period, having consistently delivered occasional M-class activity. By contrast, its southern neighbour, AR3310 delivered its M9.6 from around a day behind the limb, which in all likelihood means that the portion observable from Earth was only a fraction of its peak flux. However, this region has since decreased in complexity becoming unipolar. While these two regions dominate the risks, the main growth trend in the period was in the western sunspot group AR3305, which showed some proliferation of spots and may have been responsible for the M1 at 20/1054UTC.

All considered, solar activity is Likely to remain Moderate, with a Slight Chance of X-class throughout the period. These risks have been tuned upwards slightly relative to the raw values, in part because AR3311's proximity to the limb is making it harder to discern any Mt Wilson delta spots. In terms of the evolution, no new large regions are expected to arrive, however AR3305 leaves the disc by day four, leading to a slight decrease in flare risk by the very end of the forecast.

X Ray Flares	Level	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC)	Day 2 (00-24 UTC)	Day 3 (00-24 UTC)	Day 4 (00-24 UTC)
Probability			(%)	(%)	(%)	(%)
Active	R1-R2 M Class	Yes	70	70	70	60
Very Active	R3 to R5 X Class	No	15	15	15	10

Figure 3: 24-trace of X-Ray activity as recorded at GOES.



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Solar Radiation Storms - (High Energy Protons):

The high energy (greater than 10MeV) proton flux, as observed by GOES16 has remained at Background levels throughout and is expected to remain as such throughout the period.
AR3311 is currently the most likely source for any further enhancements, and to a lesser extent AR3305. The risk of high energy proton events is therefore not negligible, and increases slightly through the period as AR3311 transits westwards.

Radiation Storms Probability (Exceedance)	Level (cm^{-2} sr^{-1} s^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ S1**	No	10	10	15	15
Very Active	**≥ S3 ***	No	1	1	1	1
* S3 ≥ 10 MeV ≥ 1000 pfu and / or ≥ 50 MeV ≥ 10 pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$)						

High Energy Electrons Event (≥ 2MeV):

The high energy electron flux (greater than 2MeV) has remained mainly at Normal Background levels over the past 24 hours.

The forecast for the coming four days is relatively low confidence in terms of electrons. This is due to uncertainties relating to the strength and influence of CH03 (discussed in the 'Geomagnetic Storms' section) as well as the potential glancing blow of the 17 May CME. The most likely driver of higher flux levels in the four days is not expected until towards the end of the period in the form of CH06/- whereupon a 550-600km/s fast wind may prove capable of delivering Active 24-hour fluence, although not until beyond the current four-day forecast window.

Given the pollution of persistent coronal hole's effects due to CME activity on past and current rotations, MOSWOC REFM is not considered likely to offer good guidance until nearer the middle of the coming working week - assuming no new transients are emitted.

GEO Electron Environment Probability (Exceedance)	Level (cm^{-2} sr^{-1} day^{-1})	Past 24 Hours (Yes/No)	Day 1 (00-24 UTC) (%)	Day 2 (00-24 UTC) (%)	Day 3 (00-24 UTC) (%)	Day 4 (00-24 UTC) (%)
Active	**≥ 2 MeV ≥ $1x10^8$**	No	1	1	10	5
Very Active	**≥ 2 MeV ≥ $1x10^9$**	No	1	1	1	1

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